3. COST ESTIMATES

Two types of cost estimates have been generated for each of the three alternatives, a total project cost (TPC) and a life-cycle cost. The TPC is defined in DOE Order 413.3, "Program and Project Management for the Acquisition of Capital Assets," as the total estimated cost (TEC) of a construction project plus the preconstruction costs (such as conceptual design and research and development) and the costs associated with the preoperational phase, (such as training and startup costs). The TEC of a construction project is the gross cost of the project, including the cost of land and land rights; engineering, design, and inspection costs; direct and indirect construction costs; and the cost of initial equipment necessary to place the plant or installation in operation, whether funded as operating expense or construction. Given the phase of the project (feasibility), some of the cost accounts (e.g., Project Management, Engineering, Project Controls) are developed using percentages of the construction cost. These percentages are based on historical experience at the INEEL. After the initial cost estimates were developed, contingency analyses were performed for each of the alternatives. These contingency analyses rated the degree of the scope definition, the project complexity and amount of innovation required for the project. These ratings were then used to develop contingency percentages based on historical performances of other DOE projects.

The life-cycle cost estimates include the TPC as well as the costs of operations, maintenance, consumable materials, and decontamination, decommissioning, and dismantling (DD&D) of the facility. Operations labor estimates were developed from estimates of the staffing requirements. Maintenance costs were estimated as a percentage of the overall facility capital cost. Yearly usage of consumables (e.g., acid, HEPA filters) was estimated from the process flow diagrams or, in the case of the HEPA filters, operating history at existing facilities. Total power demand was estimated from the equipment lists and one-line diagrams and an average use factor was applied to determine the yearly power use. DD&D costs were determined based on the facility capital costs and factors developed by the INEEL DD&D Program. Details of the life-cycle cost estimates are provided in Appendix G (see the attached CD).

Both the TPC and the life-cycle cost include escalation, the increase in cost for the same amount of work over time, and contingency. In addition, a discounted life-cycle cost has also been computed, in which the hture costs of the facility are 'brought back" to the present using the discounting rates provided in the Office of Management and Budget Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.*

3.1 Total Project Costs

Two TPC estimates were developed for Alternative 1 so that the costs of the two non-TRU treatment alternatives, 2aP (Incineration) and 3aP (Thermal Desorption), could be compared. The total project cost for Alternative 1 with incineration is $447M (rounded), including contingency and escalation. The comparable cost for Alternative 1 with thermal desorption is $385M (rounded). Summaries of the estimates in the major elements of the work breakdown structure are presented in Tables 5 and 6. The detailed cost estimates are provided in Appendix G (see the attached CD).

Table 5. Summary of costs for Alternative 1 (Compact All of the TRU Waste) plus 2aP (Incinerate the non-TRU Waste).

Description	Estimate Subtotal ($)	Escalation ($)	Contingency ($ and %)	Total ($)
Environmental, Safety, Health, and Quality	17,651,000	1,431,000	14,064,000 73.7%	33,146,000
Design Engineering	43,987,000	3,041,000	28,935,000 61.5%	75,963,000
Procurement	101,275,000	8,213,000	67,363,000 61.5%	176,851,000
Construction	61,806,000	8,257,000	34,572,000 49.3%	104,635,000
Testing & Turnover	17,516,000	2,817,000	17,474,000 85.9%	37,807,000
Project Management	12,324,000	1,319,000	5,017,000 36.8%	18,660,000
Total Project Cost	254,559,000	25,078,000	167,425,000 59.9%	447,062,000

Table 6. Summary of costs for Alternative 1 (Compact All of the TRU Waste) plus 3aP (Thermal Desorption of the non-TRU Waste)

Description	Estimate Subtotal ($)	Escalation ($)	Contingency ($ and %)	Total ($)
Environmental, Safety, Health, and Quality	16,739,000	1,357,000	9,033,000 49.9%	27,129,000
Design Engineering	42,572,000 *	2,953,000	16,937,000 37.2%	62,462,000
Procurement	94,011,000	7,624,000	50,726,000 49.9%	152,361,000
Construction	60,099,000	8,029,000	34,007,000 49.9%	102,135,000
Testing & Turnover	13,131,000	2,111,000	8,399,000 55.1%	23,641,000
Project Management	11,687,000	1,251,000	4,812,000 37.2	17,750,000
Total Project Cost	238,239,000	23,325,000	123,914,000 47.4%	385,478,000

* Includes **$16.6M** for TRIPS type WIPP reporting system.

Given that the incinerator costs were higher than the thermal desorption costs, the technical complexity for incineration is higher, and that there is no particular advantage to volume reduction of the material to be returned to the pit, the TPC estimates for the Alternative 2b and Alternative 4a were only developed for the thermal desorption treatment of the non-TRU waste. The total TPCs for these alternatives were $463M and $551M, respectively. These costs are summarized in Tables 7 and 8. Note that the Design Engineering costs include $29M (with escalation and contingency) for a WIPP reporting system similar to the TRIPS system developed in support of the 3100m^3 project. The estimates were developed based on the designs presented in Appendix I and the equipment lists provided in Appendix F and include escalation and contingency. Escalation was based on the rates published in the INEEL Cost Estimating Guide.

Table 7. Summary of costs for Alternative 2b (Melt All of the TRU Waste) plus 3aP (Thermal Desorption of the non-TRU Waste).

Description	Estimate Subtotal ($)	Escalation ($)	Contingency ($ and %)	Total ($)
Environmental, Safety, Health, and Quality	18,324,000	1,486,000	14,347,000 72.4%	34,157,000
Design Engineering	45,03 1,000	3,105,000	32,259,000 67.0%	80,395,000
Procurement	94,727,000	7,682,000	31,917,000 60.5%	164,326,000
Construction	72,327,000	43,663,000	43,880,000 53.5%	125,870,000
Testing & Turnover	17,497,000	2,814,000	17,155,000 84.5%	37,466,000
Project Management	12,794,000	1,369,000	6,867,000 48.5%	2 1,030,000
Total Project Cost	260,700,000	26,119,000	176,425,000 61.5%	463,244,000

Table 8. Summary of costs for Alternative 4a (Thermal Desorption, Chemical Leach, and Incineration of ıe TRU Waste) plus 3aP (Thermal Desorption of the non-TRU Waste).

Description	Estimate Subtotal ($)	Escalation ($)	Contingency ($ and %)	Total ($)
Environmental, Safety, Health, and Quality	18,076,000	2,415,000	15,036,000 73.4%	35,527,000
Design Engineering	56,647,000	6,261,000	61,416,000 97.6%	124,324,000
Procurement	96,381,000	12,877,000	66,926,000 61.3%	176,184,000
Construction	68,785,000	12,980,000	58,739,000 71.8%	140,504,000
Testing & Turnover	20,977,000	5,796,000	26,136,000 97.6%	52,909,000
Project Management	12,621,000	2,382,000	11,008,000 73.4%	26,011,000
Total Project Cost	273,487,000	42,710,000	239,261,000 77%	555,459,000

3.2 Life-cycle Costs

As noted above, the LCC estimates include the TPC, operating costs (including labor and materials), and DD&D costs. These costs are escalated using the project schedule and the INEEL Cost Estimating Guide rates. These hture costs are discounted to provide a present value comparison. In this study, the operating cost is complicated by two issues.

- The cost of transporting the TRU waste to WIPP and disposing of it there
- The number of pits that will be remediated

The WIPP disposal cost is borne by the National TRU Program for the entire DOE complex. There is no "fee" charged to the various TRU generator sites. This makes it more difficult to allocate costs. Furthermore, these costs can be interpreted a number of ways:

1. The simple transportation and disposal costs, i.e., the costs for transporting the waste to WIPP and placing it in the mine
2. The costs for characterizing, packaging, and certifying the waste for WIPP plus the transportation and disposal costs
3. The costs for characterizing, packaging, certifying the waste for WIPP plus the transportation and disposal costs, plus the additional program related WIPP costs at Carlsbad Field Office (CBFO)
4. The costs for characterizing, packaging, certifying the waste for WIPP plus the transportation and disposal costs, plus the additional program related WIPP costs at CBFO plus the "pro-rated" costs of the development and commissioning of the WIPP.

As might be expected, there are a number of values associated with this WIPP disposal cost. As shown below, the value used in the estimate can drastically affect the LCC and the selection of the alternative. BBWI (EDF-3711 2003) has reviewed the various data sources and developed a disposal cost that accounts for the WIPP program costs, the waste certification, transportation, and disposal. This total cost is about $72,000/m^3$. Other values have also been used in previous analyses. In a recent audit report by the DOE Office of the Inspector General, (DOE 2003), a value of $8,177/m^3$ was used, although the report also noted that this value did not reflect the actual life-cycle cost of TRU waste disposal operations. As shown below, cases will be developed using both the disposal costs from EDF-3711 (2003) and the DOE's report (DOE 2003) to bound the effect of this parameter on the overall LCC estimate.

It was the intent of the original ROD that this action would be an interim action that would serve as a demonstration for hture remediations in the SDA. Current thinking is that the systems employed in the Pit 9 remediation should be flexible enough to be applied to other TRU pits in the SDA. Furthermore, recent court rulings indicate that it is likely that remediation of at least some of the other TRU disposal pits and trenches is likely. Given the magnitude of the costs associated with the retrieval and treatment facilities, it seems reasonable to evaluate the LCCs of the treatment facilities over the entire volume of waste to be remediated. It is not certain, at this point, how much additional remediation will be performed. As a basis of comparison, LCC estimates were developed for remediating the following:

- Pit 9 (1 acre)
- An arbitrary 4-acre retrieval (consistent with the current life cycle baseline for the Stage III project) which could hypothetically remove a substantial (–50%) portion of the TRU inventory
- An arbitrary 8-acre retrieval effort that represents an upper bound for the volume to be remediated.

As noted previously, the basis for this study assumed a 2-year operating duration for the treatment operations associated with the 1-acre area of Pit 9. For the purposes of this evaluation, it will be assumed that the operating duration per acre is constant, so the operating duration for the 4-acre retrieval would be 8 years, and the operating duration for the 8-acre retrieval would be 16 years.

This additional remediation also impacts the available space at WIPP. The volume of waste that is expected to be generated from the Pit 9 remediation is well within WIPP's current capacity. However, if additional pits and trenches from the SDA are added to the volume of waste to be sent to WIPP, WIPP's capacity may be severely challenged. This factor, while not as quantifiable as some of the costs, would indicate a preference for alternatives that provide greater volume reduction.

Using the three treatment alternatives previously described, three retrieval scenarios, and two WIPP transportation and disposal costs, a set of LCCs has been developed to aid in selecting the treatment approach to be implemented in the Pit 9 Remediation Project. The life-cycle costs for the various cases are shown in Tables 9, 10, and 11. The slight differences in operating costs between the high and low WIPP cost cases are due to the statistical nature of the estimate development.

Table 9. Life-cycle costs for 1-acre retrievals.

	High WIPP Cost ($K)			Low WIPP Cost ($K)		
	Alternative 1	Alternative 2b	Alternative 4a	Alternative 1	Alternative 2b	Alternative 4a
Capital	385,500	463,500	555,500	385,500	463,500	555,500
Operations	298,800	466,900	517,500	299,000	467,000	517,500
WIPP disposal	678,800	319,900	64,600	76,100	35,900	7,200
DD&D	79,700	88,700	99,200	79,700	88,700	99,200
Total (including escalation and contingency)	1,442,800	1,339,000	1,236,800	840,300	1,055,100	1,179,400
Discounted total	1,080,400	987,200	863,800	651,100	793,000	828,800

Table 10. Life-cycle costs for 4-acre retrievals.

	High WIPP Cost (SK)			Low WIPP Cost ($K)		
	Alternative 1	Alternative 2b	Alternative 4a	Alternative 1	Alternative 2b	Alternative 4a
Capital	385,500	463,500	555,500	385,500	463,500	555,500
Operations	791,600	1,370,900	1,622,500	792,200	1,371,300	1,622,600
WIPP disposal	2,375,800	1,279,700	258,500	266,400	143,500	29,000
DD&D	91,500	104,600	118,000	91,500	104,600	118,000
Total (including escalation and contingency)	3,644,400	3,218,800	2,554,500	1,535,600	2,082,900	2,325,100
Discounted total	2,429,000	2,062,600	1,531,400	1,069,100	1,373,200	1,407,000

Table 11. Life-cycle costs for 8-acre retrievals.

	High WIPP Cost (SK)			Low WIPP Cost ($K)		
	Alternative 1	Alternative 2b	Alternative 4a	Alternative 1	Alternative 2b	Alternative 4a
Capital	385,500	463,500	555,500	385,500	463,500	555,500
Operations	1,806,800	2,834,800	3,285,900	1,808,100	2,835,400	3,286,000
WIPP disposal	5,430,507	2,559,300	484,600	608,800	286,900	54,300
DD&D	114,100	130,500	146,100	114,100	130,500	146,100
Total (including escalation and contingency)	7,736,900	5,988,100	4,472,100	2,916,500	3,716,300	4,041,900
Discounted total	4,445,900	3,249,200	2,308,700	1,715,000	2,063,8000	2,104,500

Figure 15 plots the escalated costs (not discounted) against the WIPP disposal cost for the various cases. The graph indicates that Alternative 1 has the lowest LCC if the low WIPP costs are used but has the highest LCC if the high WIPP costs are used. The point at which Alternative 1 becomes the highest LCC shifts to the left as the number of acres to be retrieved increases, indicating that as the number of acres increases the analysis becomes more sensitive to the WIPP disposal cost.

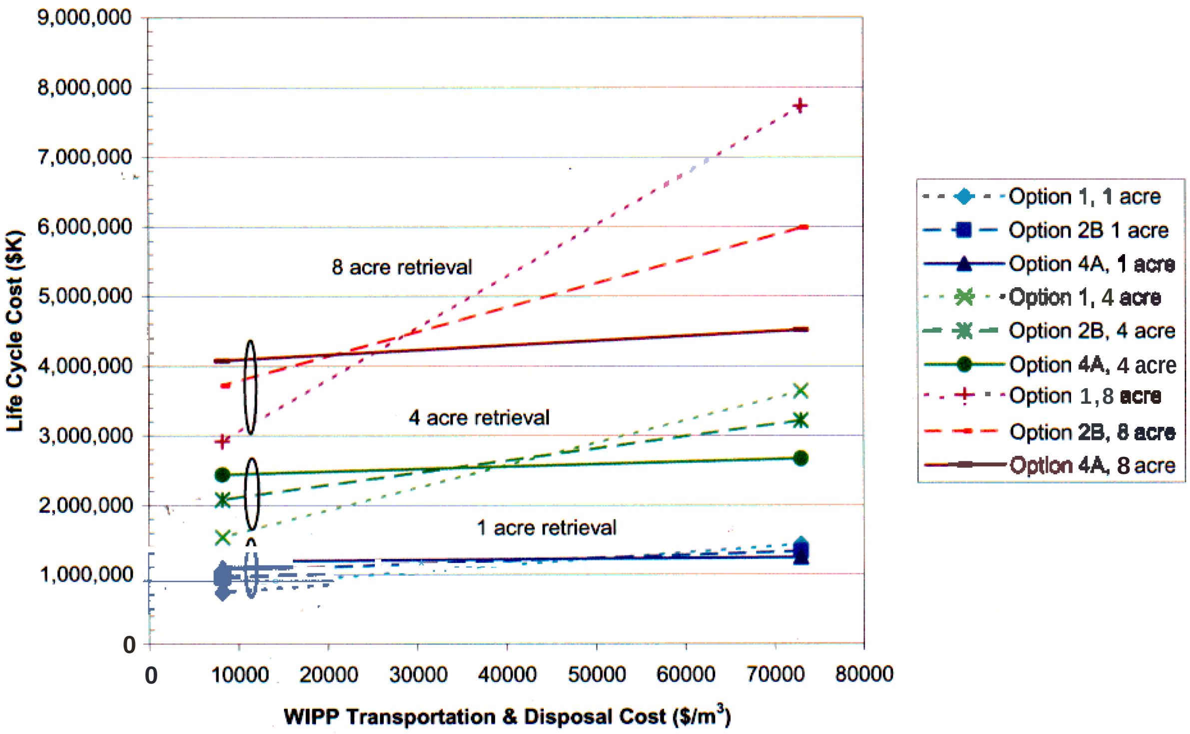

Figure 15. Life-cycle costs for the three alternatives given various retrieval areas and WIPP disposal costs.

4. SCHEDULE ESTIMATES

Several enforceable milestones have been established for the interim remedial action in the 2002 Agreement to Resolve Disputes (ARD) between DOE, EPA, and the state of Idaho. The ARD requires that DOE:

- Submit the 10% design by September 2005
- Complete the Remedial Design for Pit 9 remediation and commence construction by no later than March 31, 2007
- Commence Pit 9 remediation operations no later than 36 months after the start of construction.

This section presents the preliminary schedules that have been developed for the three alternatives and discusses how they meet or do not meet these enforceable milestones. The schedules are provided in Figures 16, 17, and 18. They have been developed assuming that the project follows the process of review and approval at Critical Decision (CD) points as directed by DOE Order 413.3, (where technically possible) and that the engineering and construction follows a traditional sequential approach (no fast-track). The construction schedule estimates are based on planning level designs and have not been optimized. As the designs develop, constructability reviews will be held to assure that features to speed construction are incorporated in the design where feasible. The schedules presented in this report are intended to highlight the differences between the three treatment alternatives and do not represent final schedule estimates. In all three alternatives, the treatment-operating period was assumed to be two years and the retrieval facilities are assumed to be constructed, tested, and ready to provide retrieved material on a schedule supporting the treatment start of operations.

All alternatives are expected to meet the first milestone, submittal of the 10% design by September 2005. In fact, the Conceptual Design (equivalent to the 10% design) must be completed a year earlier to support the start-of-construction milestone, given the durations for the subsequent CD-1 (Alternative Selection and Cost Range) review and approval cycle following the Conceptual Design, the Preliminary Design, the CD-2 (Performance Baseline) review and approval cycle, the Final Design, and the review and approval for CD-3 (Construction Readiness).

Alternative 1 provides the best chance of meeting the ARD deadlines although, as shown in Figure 16, some site preparation and building structure construction is assumed to be completed before the three-year period allowed by the ARD. This schedule also requires that DOE allow partial approval of start of construction before the Final Design phase is complete.

Alternative 2b is expected to take about 1 year longer than Alternative 1. Alternative 2b is scheduled to take longer because the building structure is larger and requires more rock excavation, the treatment systems are more complex and will take longer to install, and a trial burn, or the equivalent, will be required to prove that the air pollution control equipment functions properly. This alternative also requires some development work but this work is not expected to impact the overall schedule (see Figure 17).

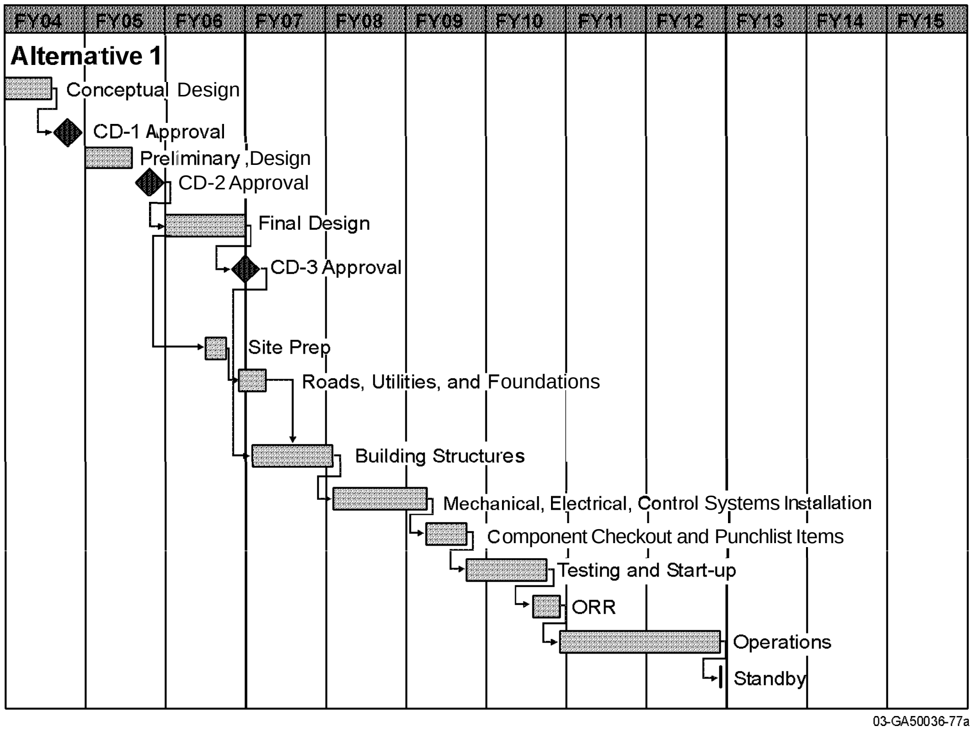

Figure 16. The schedule for Alternative 1 (Compact All).

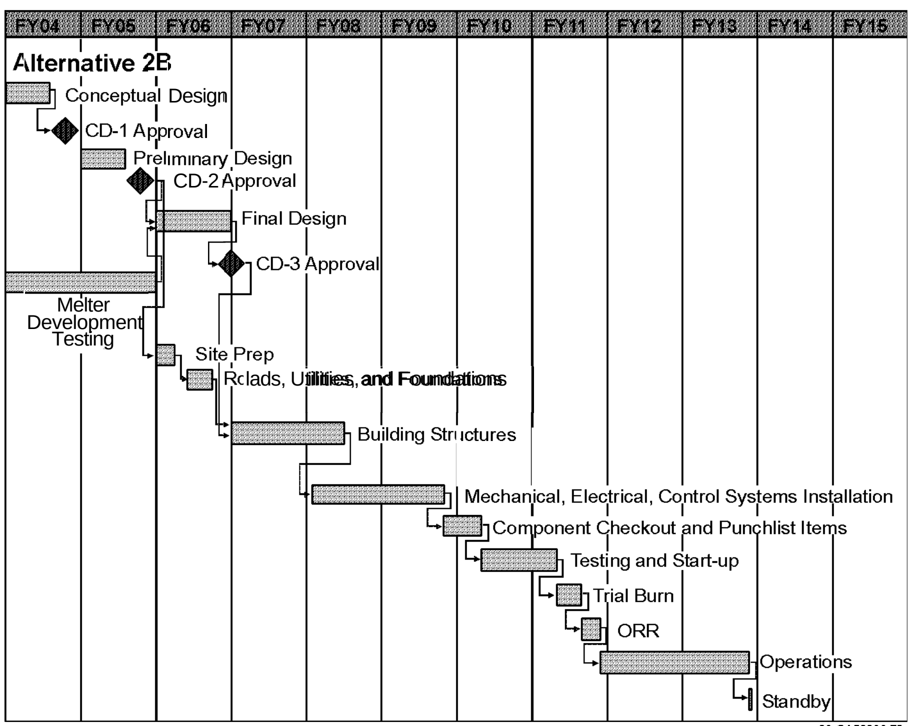

Figure 17. The schedule for Alternative 2b (Melt All).

Alternative 4a is expected to take the longest to start operations, about three years longer than Alternative 1 (see Figure 18). There are several factors that cause this increased schedule including:

- A delay of 1 year in the start of design while technology development efforts are conducted to establish the basis for design
- A much longer installation period because the systems are much more complex
- A trial burn will be required before starting the incinerator operations.

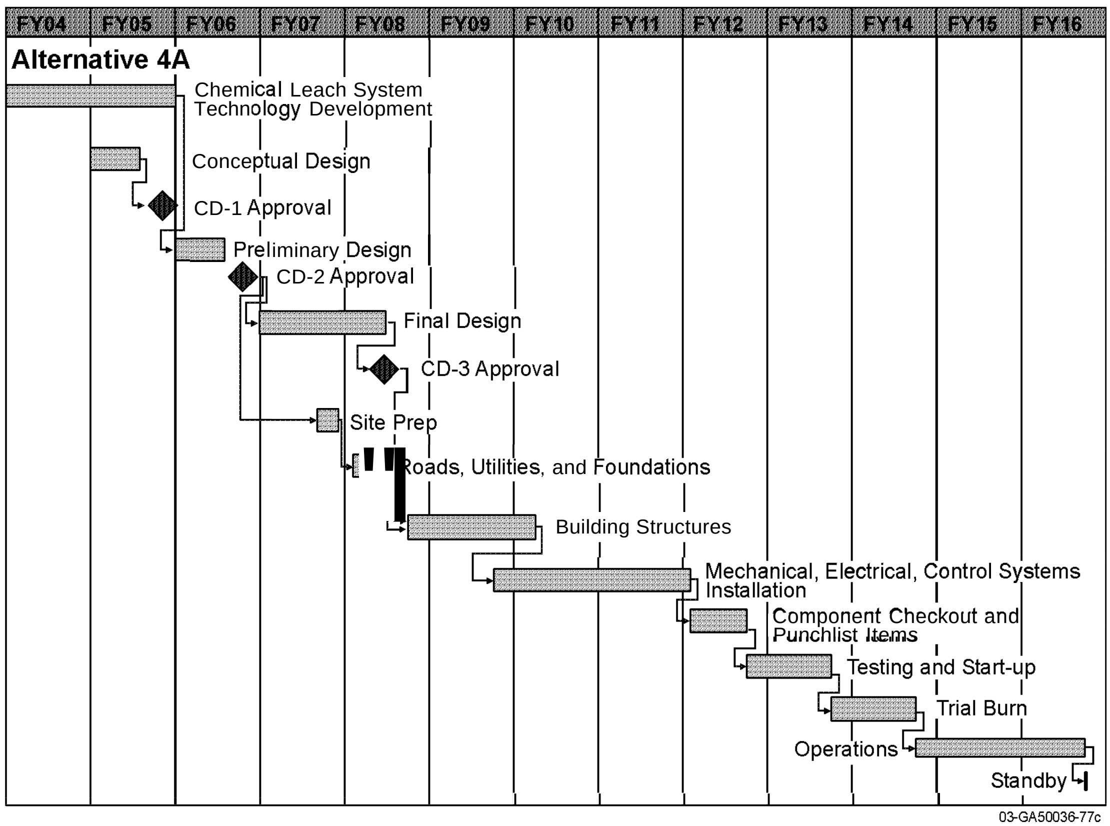

Figure 18. The schedule for Alternative 4a (incinerate, thermal desorption, and leach)

As noted previously, these schedules are not presented as the project baseline but to illustrate the differences between the alternatives. Some improvement may be achieved, as noted above, as the design proceeds. On the other hand, issues such as litigation, especially in the case of the alternatives with high temperature thermal processes, may delay these schedules further.

5. EVALUATION OF ALTERNATIVES

The CERCLA process identifies the following nine criteria for evaluating alternatives (EPA 1988) While this evaluation is not intended to replace the evaluation conducted as part of the Pit 9 ROD (DOE-ID 1993), these criteria are certainly reasonable ones to apply.

Threshold Criteria

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate regulations (ARARs)

Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. cost

Modifying Criteria

8. State acceptance
9. Community acceptance.

These criteria will be considered in evaluating the three alternatives for treating TRU material and the two alternatives for treating the non-TRU material.

5.1 Non-TRU Evaluation

The first step in the evaluation will be to select one of the two non-TRU alternatives. As discussed previously, and shown in the drawings in Appendix I, either Alternative 2aP (Incineration) or Alternative 3aP (Thermal Desorption) can be used to treat the non-TRU material with any of the three TRU alternatives. For the purposes of this evaluation, reduction of the VOC concentrations will be addressed.

Table 12. Evaluation of the non-TRU alternatives based on the CERCLA criteria.

Criteria	Evaluation
Threshold Criteria	
Overall protection of human health and the environment	Both Alternative 2aP and Alternative 3aP are expected to remove the contaminants of concern, i.e., remove the VOCs equally well. Therefore, they both satisfy this criterion.
Compliance with ARARs	Implementations of either Alternative 2aP or Alternative 3aP are expected to comply with the ARARs. Therefore, they are both to meet this criterion.
Balancing Criteria	
Long-term effectiveness and permanence	In either alternative, VOC concentrations in Pit 9 will be permanently reduced to levels that are protective of human health and the environment, therefore these alternatives are equal.
Reduction of toxicity, mobility, or volume through treatment	Both alternatives are expected to reduce the VOC concentrations to levels that result in risk levels below acceptable thresholds. Alternative 2a will provide greater volume reduction of the material returned to the pit but this feature does not appear to provide any significant advantage.
Short-term effectiveness	The short-term effectiveness, that is, the protection of human health and the environment during construction and implementation, for these alternatives are equal.
Implementability	Technically, these alternatives are deemed equal in this criterion. In terms of schedule, however, Alternative 3aP is expected to be quicker to implement because, among other things, no trial burn is anticipated for the alternative.
cost	Based on the planning level cost estimates (see Appendix G) developed for this study, Alternative 3aP is clearly less costly than Alternative 2aP.
Modifying Criteria	
State acceptance	Given that either alternative complies with all the ARARs, the State of Idaho is expected to be satisfied with either alternative.
Community acceptance	Given the history of resistance of various stakeholders to incineration-like technologies, alternatives 3aP is clearly less risky than Alternative 2aP.

Alternative 3aP (thermal desorption) is considered the better alternative for removing the VOC contamination from the non-TRU material that will be returned to the pit because:

- It provides the same (or similar) degree of protection of human health and the environment at lower cost
- It can probably be accomplished in a shorter schedule,
- It is not expected to meet the same community resistance as an incineration process.

5.2 TRU Alternative Evaluation

This section evaluates the three TRU alternatives to provide data for the Alternative selection process.

5.2.1 Threshold Criteria Evaluation

All three alternatives are considered to meet the threshold criteria, i.e., protection of human health and the environment and compliance with ARARs. This criterion is not considered a discriminator.

5.2.2 Balancing Criteria

The evaluation of the three TRU alternatives against the balancing criteria is provided below.

Long-term Effectiveness and Permanence

With respect to the TRU hazard, all three alternatives are deemed equal because all remove the same amount of TRU from Pit 9 and dispose of that material in WIPP. With respect to other hazardous constituents, the disposal of this material in WIPP should provide satisfactory (and equal) long-term isolation from the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment

The best immobilization and reduction of toxicity is achieved with Alternative 2b, which either destroys the contaminants due to the high temperatures (e.g., the VOCs) or ties them up in the slag from the melter. Various studies have shown that this slag provides very good immobilization. However, given the characteristics of the WIPP disposal site, the value of this immobilization is somewhat moot.

The reduction of volume is particularly important to WIPP. The current WIPP capacity of 175,600 m^3 for both contact handled (CH) TRU waste and remote handled (RH) TRU waste was set by the WIPP Land Withdrawal Act, signed in 1992. Subtracting the 7,080 m^3 allowed for RH TRU, the CH capacity is 168,520 m^3. According to the National TRU Management Plan (DOE 2002), the total CH volume to be disposed is 113,300 m^3. This leaves 55,200 m^3 for disposal of additional wastes that are not included in the plan but could (or will) be generated at various sites across the country. The selection of the treatment alternative, especially if more than 1 acre is to be remediated, can significantly impact the remaining WIPP capacity.

Table 13 summarizes the performance of the three alternatives with respect to the volume reduction of the waste. Alternative 1 provides no volume reduction (actually a slight volume increase). Generally, a compaction technology would be expected to provide some volume reduction but this waste stream is not typical of most TRU waste streams that have been evaluated in the past. The single largest factor is that nearly 70% by volume of the TRU material is soil and the compaction that can be achieved with soil is minimal. Alternative 1, even for the 1-acre retrieval, uses 13% of the remaining WIPP capacity. If the results are extrapolated to an 8-acre retrieval, the waste volume exceeds the WIPP capacity. The best volume reduction of the TRU fraction of the retrieved material is achieved in Alternative 4a, which, even under the 8-acre scenario, only requires about 7% of the remaining WIPP capacity. It is important to note that other sites may, or more probably will, have additional demands for disposal capacity so volume reduction capability becomes even more important.

Table 13. The waste volume reduction of the three alternatives.

Total Volume of Transuranic Waste Removed from Pit 9: 14,000 m^3 Total Initial Volume Transuranic Waste: 7,000 m^3					
	Ship to WIPP (m^3)	% volume reduction to WIPP	Return to Pit 9 (m^3)	Pit 9 return ratio	Secondary waste to off-site treatment (m^3)
Alt 1 (Compact All) + Alt 3aP (thermal desorption and return to pit)	7,500	-7%	6,300	0.5	300
Alt 2b (Melt All) + Alt 3aP (thermal desorption and return to pit)	3,500	50%	6,500	0.5	300
Alt 4a (thermal desorption, leach, and incinerate) + Alt 3aP (thermal desorption and return to pit)	500	93%	13,600	1.0	300

WIPP = Waste Isolation Pilot Plant

Short-term Effectiveness

The protection of human health and the environment during construction and implementation of all three alternatives are considered essentially equal. The high temperatures of Alternative 2b and the high temperatures and chemical hazards of Alternative 4a potentially pose higher risks to human health and the environment during construction and implementation than that of Alternative 1.

Implementability

There are distinct differences in the technical and administrative feasibility of these three alternatives. Alternative 1 is similar to the AMWTP, which has recently completed construction and it is rated highest in this category. Alternative 2b is rated the next highest. Facilities that melt waste using electric arc, plasma arc, or similar technologies have been built in various locations around the world but none have been demonstrated on the types of waste expected from Pit 9. Alternative 4a is rated lowest. From a technical perspective, the chemical leach process requires additional research to verify the performance of the process and establish certain design parameters such as the ultimate TRU dissolution effectiveness, the filtration efficiency in separating the dissolved TRU from the remaining soil, and final volume reduction. Prototype testing is needed to confirm equipment selection and design concepts for critical components such as filters, pumps, and the calciner. The overall concept, that is, thermal desorption, chemical leach, and incineration is complex, which presents its own set of complications, even in a technically mature process. These complications will also result in operational complexities in start-up, system integration, and day-to-day operations.

cost

The LCC is comprised of the TPC (capital) costs, the operating costs, the WIPP transportation and disposal costs, and the facility DD&D costs. Figure 19 shows the relative contributions of these categories to the overall cost for four cases:

1. Alternative 1 with low retrieval volume and low WIPP cost
2. Alternative 1 with high retrieval volume and high WIPP cost
3. Alternative 4a with low retrieval volume and low WIPP cost
4. Alternative 4a with high retrieval volume and high WIPP cost.

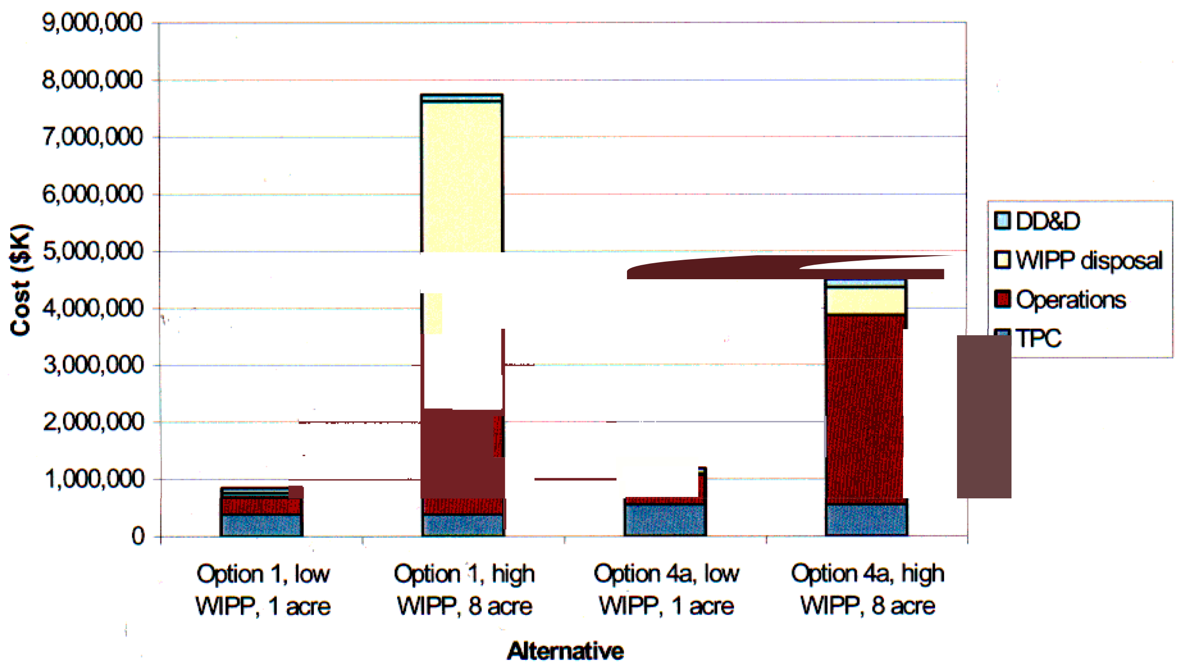

Figure 19. The life-cycle costs for Alternatives 1 and 4a, with a high and low disposal costs.

As shown in Figure 19, discussed previously, the LCCs for the Pit 9 treatment alternatives were estimated for two different WIPP disposal costs and three retrieval mas (1 acre, 4 acre, and 8 acre) and these factors drastically affect the overall LCC. For a 1-acre retrieval and with low WIPP costs, Alternative 1 is the best. For an 8-acre retrieval and with high WIPP costs, Alternative 4a is clearly the best.

5.2.3 Modifying Criteria

It seems reasonable to assume that the state of Idaho would accept my Alternative that achieves the remediation goals, is protective of the environment, and complies with the ARARs. The community acceptance, however, is less likely for the alternatives that involve high temperature thermal processes. AMWTP history has shown that while the community may accept retrieval and TRU handling operations, it is much less likely to accept incineration (or incineration-like) alternatives.

6. RISK IDENTIFICATION AND AREAS FOR FUTURE STUDY

The risk management process to be used during execution of the Pit 9 Remediation Project follows the general risk management process described in DOE Manual 413.3-1, Chapter 14, "Risk Management". However, the general process has been tailored to suit the size, complexity, and unique attributes of the Pit 9 Remediation Project and consists of the following major steps.

- Step 1: **fisk** management planning (including self-assessment for continuous improvement)
- Step 2: **fisk** identification
- Step 3: **fisk** quantification
- Step 4: **fisk** response (e.g., avoidance, reduction, mitigation, or acceptance)
- Step 5: **fisk** impact determination
- Step 6: **fisk** tracking and reporting.

These process steps will generally be completed sequentially with iterations of the complete process performed at each project phase to support the critical decision approvals of the DOE Order 413.3 process. However, in some cases, individual risk items can be addressed in a real-time fashion. In such cases, the process allows the flexibility to begin at Step 2 and proceed through Step 6, either immediately or on a scheduled basis, depending on the judgment of the risk coordinator, project manager, or the risk management team. Integration of steps in the overall risk management process is shown in Figure 20. Tailoring of the risk management steps and associated activities, including execution guidance, is provided in the project Risk Management Plan.

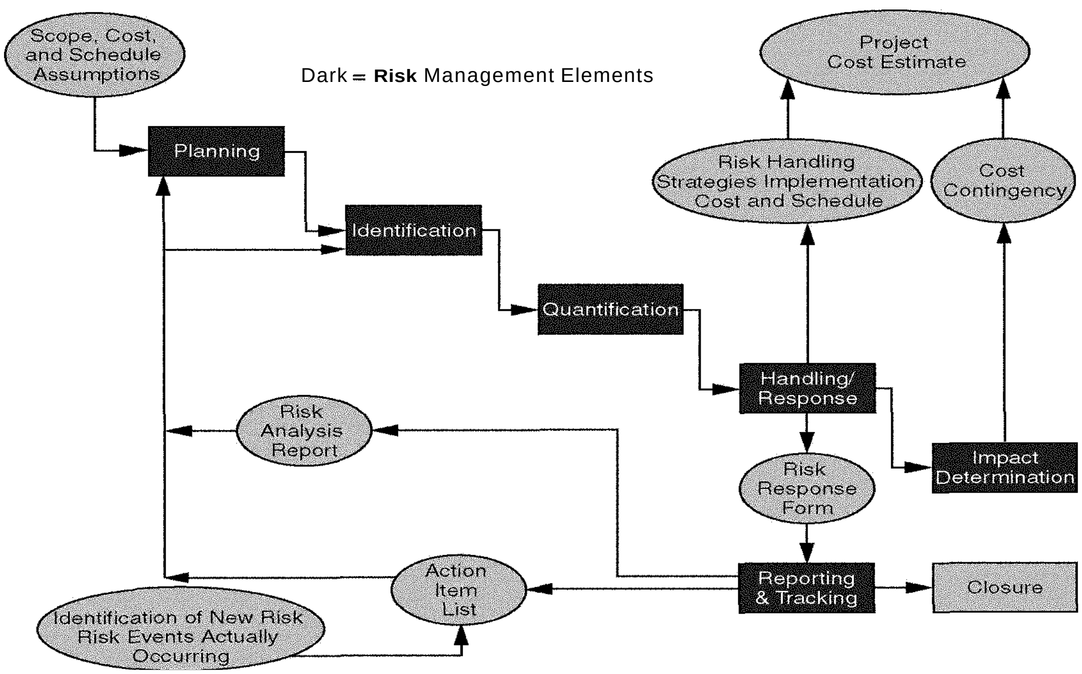

Figure 20. Risk management functional flow diagram (DOE 2000).

At this stage of the project, the emphasis is placed on planning and risk identification. The planning phase of the risk management process has been accomplished with the release of the Risk Management Plan (DOE 2000). The risk identification process is currently underway. The following sections identify the high-risk items that will significantly affect the project performance if they are not resolved. Where applicable, areas for hture study are identified to aid development of mitigation of these risks.

6.1 Programmatic Risks

Programmatic risks include changes in program requirements or resources, such as changes in regulatory requirements or interpretation of those requirements, unfavorable stakeholder response to a selected alternative, or loss of funding that, ultimately, affects either the cost or schedule for the project. These risks are classified as programmatic risks at this time, rather than cost or schedule risks, because they will be managed from a program perspective, rather than an engineering or construction approach. To some extent, the programmatic risks identified below indicate areas where treatment requirements for the Pit 9 Remediation Project are still being resolved. These risks must be resolved in a timely manner to assure that the project will meet the ARD mandated deadlines.

6.1.1 TRU Contamination Action Level

As proposed in the mission analysis and definition document (INEEL 2002), this study has been based on a TRU contamination action level of 100 nCi/g rather than the 10 nCi/g level specified in the 1993 Interim Action ROD. This decision was based, in part, on the fact that one criterion for disposal at WIPP is that the waste be contaminated at levels greater than 100 nCi/g. Implementation of the 10 nCi/g action level would have effects in many areas – technologies to be applied, volumes of waste generated, facility throughputs, and identification of additional disposal sites for the 10 nCi/g to 100 nCi/g fraction (or long term storage in the absence of such sites), to name a few. To help resolve this issue, a study will be conducted to provide data on the long-term risk using the higher action level.

It should also be noted there is a discrepancy between the ROD definition of TRU and WIPP's definition of TRU, in that the ROD definition includes Pu-241 while WIPP's does not because it has a half life of less than 20 years and is not an alpha emitter.

6.1.2 90% Volume Reduction Goal

The selected alternative in the ROD provided 90% reduction in the volume of material that would be treated (i.e., the volume of material contaminated at levels greater than 10 nCi/g). Alternative 4a is similar to the alternative selected in the ROD and, based on process design estimates at this time, provides a similar degree of reduction in the volume of the TRU material. Therefore, the risk that the alternative could be rejected because it does not meet volume reduction criteria is nil. Alternative 2b provides a lesser reduction in the volume of the contaminated material but, due to the encapsulation of the TRU in the slag and destruction of hazardous organic compounds, reduces the toxicity and mobility of the treated material as well. Again, the risk that this Alternative would be not be accepted is low. Alternative 1 provides essentially no volume reduction and does not destroy any hazardous material in the TRU material. However, given that the TRU material is disposed of in WIPP, the designated geologic disposal facility for TRU waste, and that WIPP's performance assessment does not take credit for the form of the waste, the risk this Alternative would be rejected because it does not meet the 90% volume reduction criteria is also considered to be low.

A second concern regarding volume reduction of the TRU material is the capacity of WIPP. While the volume of TRU waste generated from the Pit 9 interim remediation will not tax WIPP's capacity, extending the remediation to the remaining TRU pits and trenches could do so. This issue is currently being addressed with the National TRU Program. Resolving these concerns is needed before selection of the final treatment alternative.

All the alternatives in this report provide a reduction in the toxicity of the non-TRU material (treatment of the VOCs). The selected alternative in the ROD did not address this hazard for materials that would be returned to the pit.

6.1.3 Contaminants of Concern for the SDA

This study has been based on treatment of the VOC contamination in the material to be returned to the pit followed by stabilization to prevent subsidence. The SDA (OU 7-13/14) comprehensive ROD may identify other contaminants of concern (COCs) such as radionuclides or hazardous chemicals beyond those identified in the 1993 Interim ROD. In a related issue, the allowable concentration of contaminants in the material to be returned to the pit must be established as well.

6.1.4 Stakeholder Acceptance

As noted previously, surrounding communities and environmental groups have expressed strong opposition to high temperature thermal technologies. As a result, low temperature technologies have been preferred.

6.2 Technical Uncertainties and Areas for Future Study

Technical risk can be defined as the risk that uncertainties in the process technology, design, or implementation can cause cost, schedule, or performance impacts. These risks can be hrther subdivided into the following subcategories:

- Insufficient understanding of the material to be processed or the process fundamentals
- Improper design, such as improper equipment selection or faulty implementation of the process engineering
- Failure of the procured equipment to meet the specifications of the design
- Improper installation of the equipment that results in failure of the system to perform as specified.

At this stage of the design, the risk identification and mitigation efforts are focused on the first two items in the list above. As the designs become more detailed, the specific equipment and implementation risks can be more accurately identified and assessed. Some of the risks and recommendations for hture studies related to the chemical, physical, and radiological properties of the waste and areas for the technology development are discussed below.

6.2.1 Waste and Soil Characterization

The extent of TRU and VOC contamination in the adjacent soil, either from migration of the contaminants in-situ or from cross contamination during retrieval operations, has not been quantified. As noted previously, this study was based on the assumption that 50% of the waste and 50% of the soil is

TRU. Given the quantity of soil and the limited volume reduction of the soil fraction in Alternatives 1 and 2b, this assumption is particularly critical to the technology selection and design of the system. If substantially less soil is TRU the WIPP transportation and disposal costs would be much less, reducing the preference for the more complex treatment processes. This reduction in TRU soil volume would also impact the estimated volume reductions, especially for Alternative 4a because most of the volume reduction is obtained by treating the soil. Of course, the opposite is also true, in that higher soil contamination levels would tend to favor the higher volume reduction technologies and increase disposal costs. This uncertainty could also result in significantly over-sizing or under-sizing process equipment.

In addition to the quantity of contaminated material, data is also needed on the chemical and physical characteristics of the wastes and soil. For instance, the quantity of water in the soil will affect equipment sizing, particularly in the thermal desorption, melting, and incineration processes. The physical properties of the material (e.g., the organic set-ups) may present material handling problems for any of the alternatives considered. Obtaining the necessary data from the GEM project operations and testing with simulated material will be critical to the success of the treatment processes.

In addition to the various properties of the waste and soil, the location of the various materials in the pit can also significantly affect the throughput or storage requirements. These feasibility studies were developed assuming the quantity of each waste type is distributed evenly over the retrieval area. However, the waste in the pit is not distributed evenly and the actual distribution will affect the throughput required. Compilation of data on the spatial waste distribution has started and development of a simulation of retrieval and treatment processes would provide valuable information regarding the sizing and optimization of the retrieval and treatment operations.

6.2.2 High Radiation Objects

There is anecdotal evidence that there are lead-lined drums of waste in Pit 9. These drums would have been lined to reduce the surface dose rates to acceptable levels. Additional information is needed to estimate the types of fields that might be expected from these drums when they are breached, either during retrieval or in the treatment processes. This information would be used during the design of equipment and processes to assure that exposures are maintained as low as reasonably achievable.

6.2.3 Criticality

The potential for accumulating a sufficient amount of fissile material from the pit in a geometric configuration that could cause it to go critical is extremely low. Nonetheless, given the severity of the consequences of such an event, controls will be put in place to monitor the amount of fissile material in the plant and assure that the potential for achieving a criticality is even further reduced. Unfortunately, any system that has the potential for hold up of material will complicate the design of these controls. For instance, the shredder will have areas of accumulation that will have to be specifically addressed. Similarly, the rotary kiln incinerator could collect material in feed or discharge areas or within the kiln itself.

It will be very important to establish requirements early in the design and evaluate concepts with appropriate personnel to assure that the control systems will perform adequately. As the design (or construction) efforts proceed, the impact of changes to these systems will be much more severe.

Both the GEM data and Acceptable Knowledge activities should also provide data regarding the fissile material quantities.

6.2.4 Waste Receiving and Preparation Technology Development

While the technology for handling soil and debris has a long history, the adaptation of existing technology to high contamination applications has not been demonstrated. Soil moisture content (and other properties) may affect conveyance system performance. Conveyance systems may also result in significant cross contamination. In particular, the processing rate for the sorting deck needs to be evaluated because the throughput of this operation may determine the requirements for the rest of the processes. It is recommended that these operations be demonstrated in a mock-up to provide better data on equipment selection, throughput, and operator interfaces.

6.2.5 TRU Assay Technology

Current assay technology has been demonstrated for 100 nCi/g levels on relatively well-characterized waste compositions. The heterogeneous nature of the "as retrieved' material, particularly if significant container degradation has occurred, is expected to exceed the assumption of homogenous or well characterized waste matrices used in most assay system calculations and is expected to require segregation to support accuracy at 100 nCi/g levels. Data from recent WIPP certification of a box/drum assay system (Franco 2001) has indicated minimum detectable concentrations of about 25 nCi/g or higher, depending on the waste matrix. Furthermore, the presence of high concentrations of Am-241 may also present problems to the assay equipment. It is possible that development of systems with the required accuracy in soil and debris assay will be more complex than currently estimated. This risk is much more likely if the TRU action level remains at 10 nCi/g. Development of conveyor systems for assaying soil and demonstration testing of both box and conveyor systems are recommended.

6.2.6 Thermal Desorption Technology

The thermal desorption technology is straightforward, however, as mentioned previously, the material handling properties of the retrieved material are unknown. In particular, the organic sludges may pose special material handling and cross contamination issues. GEM data and prototype testing of simulated sludge and soil is recommended. As noted earlier, the moisture content of the retrieved material will also affect the system throughput.

6.2.7 Incineration Technology

Incineration of hazardous waste has been in production for many years but the challenges of assuring containment of the high alpha waste have posed significant problems in the past. Previous experience at the Process Experimental Pilot Plant (a facility built at the INEEL for incinerating TRU waste) indicated several concerns, including:

- The feed and discharge systems must be designed to assure isolation of the contaminated, high temperature environment from the environment. The high temperatures can cause the feed to become "sticky" and plug the feed system. The discharge system will have to deal with cooling of the ash, managing klinkers (lumps of fused material), and packaging of the material without spreading contamination.

- The combination of rotating seals, high temperature, and the potential for intermittent overpressure (due to periods of high rates of combustion) make the mechanical design particularly challenging. These seals are typically large (on the order of feet) and maintaining the necessary tolerances over the full range of thermal expansion has been shown to be difficult. Testing of the design at temperature in non-radiological conditions should be performed.

- Construction of a prototype system to evaluate designs and demonstrate operation in a non-radioactive environment is strongly recommended.

- Maintenance of the kiln in the contaminated environment is also a significant challenge. The refractory lining of the kiln will have to be inspected periodically and eventually replaced, if the Stage III treatment facility is used to remediate other pits and trenches. In a typical incinerator system, this is accomplished “hands-on”.

- Plutonium hold-up (as discussed in the preceding section on criticality) is also a concern with the incinerator system.

6.2.8 Melter Technology

The technical risks of the incinerator systems are very similar to those associated with the melter systems. There are existing melter installations for treating nuclear waste but none of them have been demonstrated on the waste and soil streams anticipated for the Pit 9 action. There are a number of areas that need to be investigated if Alternative 2b is selected. The melter throughput, contaminant carryover, refractory life, electrode life, slag pouring characteristics, and melter maintenance in high alpha environments are some of the items that should be investigated in a prototype during the Conceptual Design phase.

It should be noted that the major risk associated with Alternative 2b is community acceptance rather than technical viability.

6.2.9 Chemical Leach

The chemical leach process proposed in Alternative 4a clearly poses the highest risk of the technologies considered in this report. It is the least well demonstrated and has no production analog. In general, there is adequate data in the DOE complex for plutonium dissolution on well-characterized feeds but uncertainties in the form of the plutonium in the pit and the impacts of processing the plutonium in the presence of soil and other wastes presents unique challenges. Plutonium oxy-hydroxides are chemically soluble in hot nitric acid and are believed to dominate the plutonium inventory in the pit. However, heat-treated forms are much less soluble, and are suspected in the pit wastes. The actual distribution between these two forms is unknown, and the actual performance of the conceptual leach process can only be approximated assuming most of the plutonium will be dissolved. Precipitation of the plutonium with oxalic acid is also a well-known process, but the impacts of co-dissolved species from the waste is unknown and cannot be determined without experimentation. The recovery of plutonium from the leach solution can only be estimated based on limited data.

Equipment selection for these severe processes is also a concern. If Alternative 4a is to be pursued, an initial research and development effort is needed using some of the material retrieved during the GEM project to establish basic design parameters. Once these parameters are established, prototype testing with subscale equipment is strongly recommended to demonstrate the equipment selection before major procurement activities are undertaken. While Alternative 4a was based on the nitric acid processes that have been employed in plutonium reprocessing efforts in the past, this is not the only technology available. It is also recommended that other processes be investigated with the intent of reducing the technical risk to the project. It is expected that substantial cost differences would be found.

6.3 Cost Risks

An evaluation of the degree of technical maturity, project definition, and project complexity was performed for each of the alternatives and the perceived cost risk is reflected in the contingency applied for each of the estimates. The overall contingency applied to each of the estimates is noted in the tables in Section 3.1. Alternative 1 is considered to have the least schedule risk because the technologies employed are the least complex and closest to production demonstration. In fact, if certain regulatory and contractual issues can be resolved, there is the possibility that there may be some cost reduction due to the use of existing resources at the INEEL (the AMWTP facilities). Alternative 2b and Alternative 4a have less production experience and are therefore are more risky. Obviously, there are no existing assets that can be leveraged to support these treatment alternatives.

6.4 Schedule Risks

The need for more intensive technology development translates directly to higher schedule risk. Again, Alternative 1 is considered to have the least risk because it is closest to the production scale basis. The other alternatives will require more development and, when less is known regarding a technology, it will generally take longer to mature that technology to a production level.

In addition to the schedule risks resulting from the level of technology being applied, there are also the more conventional issues of design, construction, and checkout schedule risks. It is likely that the limited space available at the site would impact the construction schedule significantly if the facilities are located as shown in these studies. It will be worthwhile, from a schedule and cost perspective, to consider, in subsequent design efforts, alternate locations for the treatment facility that will allow more design flexibility and better construction access.

7. CONCLUSIONS AND RECOMMENDATIONS

As noted in the preceding section, the selection of the treatment alternative is complicated by the uncertainties in the volume of material to be retrieved, the amount of TRU and VOC contamination in that material, and how much it will cost to dispose of TRU material at WIPP. The data points on the left hand side of Figure 15 show that Alternative 1 (Compact All) has the lowest life-cycle cost for any retrieval area (1,4, or **8** acre) if the low WIPP disposal costs are used. However, the entire remaining WIPP disposal capacity would be used (or exceeded) if retrieval of more than 4 acres is necessary, since this option has very little volume reduction. If the high WIPP disposal costs are used (right hand data points in Figure 15), Alternative 1 becomes the most expensive in all cases. Additionally, Alternative 1 does not provide the volume reduction specified in the Pit 9 ROD and thus will require additional negotiations with the agencies. Negotiations will be necessary in any case because all the alternatives are predicated on changing the TRU action level from 10 nCi/g to 100 nCi/g.

Alternative 2b provides greater volume reduction and a more stable waste form than Alternative 1. However, as shown in Figure 15, Alternative 2b is more expensive than Alternative 1 when using the low WIPP costs is never the least expensive option, no matter the WIPP costs or the retrieval area. Still, Alternative 2b is deemed less technically risky than Alternative 4a.

Alternative 4a meets the ROD requirements for volume reduction but is always the most expensive when the low WIPP disposal costs are used. It is the least expensive when the high costs are used. However, it involves the most technical risk, has the highest capital cost, and current schedule estimates do not match the ARD deadlines established for the program.

There are complex-wide issues related to this evaluation and obtaining definitive answers will be difficult and time consuming. Furthermore, changes in the amount of contaminated material to be treated (currently 50% of the waste and 50% of the soil) will affect the analysis as well. However, noting that much of the capability required to segregate, assay, and package the retrieved material and treat the non-TRU fraction contaminated with VOCs is common to all the alternatives points to a reasonable path forward in the interim. Until additional data is available from the project regarding the extent of TRU contamination in the retrieved material, decisions can be made regarding the total area to be remediated, and assessments of WIPP disposal costs and capacities can be agreed upon, it is recommended that the Pit 9 Remediation Project pursue the development of these common systems. The WRPF and non-TRU TD systems are needed to support any of the alternatives and development of additional design detail would be productive. These systems would allow retrieval, packaging, and interim storage so that additional treatment capability, if needed, could be added after the excavation of Pit 9 is complete.

In conclusion, it is recommended that, at a minimum, design of the WRPF and non-TRU TD facilities proceed. It should be noted that while these alternatives provide "stand-alone" capability for segregation and treatment for the purposes of this report, DOE has existing assets in the form of the AMWTP facilities. Use of these existing assets, to the extent possible, will be pursued, thereby reducing the initial capital cost of Pit 9 remediation.

Furthermore. it is recommended that:

- Efforts to establish a consensus on the life-cycle TRU waste disposal costs continue with the National TRU Program
- The number of pits and trenches to remediate be established

- Data from the GEM project be evaluated to more accurately determine retrieval and treatment requirements.
- Technology development and prototype testing of the thermal desorption process and sorting deck be pursued as soon as practical.

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